International Atomic Energy Agency
GENERAL CONFERENCE

GC

GC(42)/INF/14
22 September 1998

GENERAL Distr.
Original: ENGLISH

Forty-second regular session
Item 12 of the provisional agenda (GC(42)/2)

MEASURES TO STRENGTHEN INTERNATIONAL CO-OPERATION IN NUCLEAR, RADIATION AND WASTE SAFETY

International Conference on Topical Issues in Nuclear, Radiation and Radioactive Waste Safety

1. An International Conference on Topical Issues in Nuclear, Radiation and Radioactive Waste Safety was held in Vienna from 31 August to 4 September 1998, organized by the Agency. The Attachment to this document, as foreshadowed in para. 7 of GC(42)/INF/5, summarizes the main conclusions from the Conference.

2. The Attachment has seven parts: Part A is the Conference Chairman's summary of the main findings and conclusions of the conference, and Parts B–G are more detailed summaries by the Session Chairmen of the main findings and conclusions of each of the six major topical sessions of the conference, as follows:

- Part B: Safety Management;
- Part C: Occupational Radiation Protection: Trends and Developments;
- Part D: Backfitting, Upgrading and Modernization of Nuclear Power Plants;
- Part E: Situations of Chronic Exposure to Residual Radioactive Materials: Decommissioning and Rehabilitation and Reclamation of Land;
- Part F: Radiation Safety in the Far Future: The Issue of Long Term Waste Disposal; and
- Part G: Regulatory Strategies.

INTERNATIONAL CONFERENCE ON TOPICAL ISSUES IN NUCLEAR, RADIATION AND RADIOACTIVE WASTE SAFETY

PART A

CONFERENCE CHAIRMAN'S SUMMARY OF FINDINGS AND CONCLUSIONS

Introduction

When the IAEA decided to organize the present Conference, it was realized that it would be a major challenge to retain the interest of the three groups of people — nuclear safety, waste management and radiation safety experts — who would be attending. It is my perception that this challenge has been met to a very significant extent, and the high level of attendance and wide range of discussions after each of the sessions confirm this. Therefore, it is my pleasure to thank everyone on your behalf who contributed to this successful outcome: the IAEA management and Secretariat, the many experts who participated in preparing and presenting papers and the Panel members on Wednesday.

I believe there were two main objectives in organizing this Conference:

(1) To share information and experiences amongst the experts from the three closely related but subtly different fields; and

(2) To seek common themes for future work.

I certainly believe that both of these objectives have been achieved. I'm sure that each of us has learned something new and useful from our colleagues here. I have also perceived a couple of common themes for future work.

One is the need for as much simplicity and transparency in our technical terms and acceptance criteria as possible so as to enable both better harmonization within the radiation industry and closer collaboration with other relevant industries and regulators.

The second point is that we need to be more positive in our attitude towards communicating with the public. I think that the excellent Panel discussion on Wednesday afternoon demonstrated that we cannot treat public communication and consultation as an optional add-on. While members of the public do not have either the technical capability or the role to make detailed operational or regulatory decisions, they do have the right to be kept informed about safety issues and to be reassured that the industry and regulators are working to accepted, transparent criteria. They also need to have confidence in the absolute integrity of the regulator as an independent, technically competent watchdog of their interests.

I would now like to summarize a few of the major points that have arisen during the Conference on the six issues covered.

Safety management

Strong economic performance in the nuclear business must be driven by excellence in nuclear operation and uncompromising safety. In recent years, the electrical utility industry as a whole, and more specifically the nuclear component, has been buffeted by change. Shortfalls in the management of safety have been occurring even in States with well established nuclear programmes. Economic, political, industrial, social, technological and organizational changes are likely to make change a continuous reality for the industry. A strong and durable system for managing safety, which enables senior utility managers to maintain a focus on safety while adapting to change, is essential for strong long term performance of nuclear installations. In order to promote strong sustainable safety cultures and the achievement of good safety performance while maintaining competitive economic results in times of change, national organizations, with the support of the IAEA, should:

- Develop a more vigorous oversight process for utility corporate and nuclear installation management and regulators in the management of operational safety. This would involve development of monitoring processes and qualitative and quantitative performance indicators to oversee the effectiveness of safety management processes;
- Develop operational safety process services with the ability to assess the effectiveness of the management of operational safety within a utility and provide assistance in areas requiring improvement. The IAEA should foster continuous improvement in safety at nuclear installations worldwide by providing senior utility management with the capability to assess and correct their own performance in the management of safety;
- Develop and use the safety management tools necessary to help reduce risk and ensure nuclear installations remain at all times within their design basis; and
- Evaluate how the rapidly developing Internet and World Wide Web can best be harnessed to assist the nuclear industry to exchange safety information and to train and encourage the next generation of technical specialists.

Occupational radiation protection

Much progress has been made in the development of radiological safety standards for occupational exposure and, in many cases, in the application of these standards. The current international standards provide a suitable basis in general but there would appear to be a need for some further developments. In particular further practical guidance is needed on: the control of exposure to natural radiation in specific circumstances, including air crews; the implementation of the principle of optimization of radiation protection; the designation of areas; the protection of occupationally exposed pregnant women; and the need to measure routinely both penetrating and superficial doses from external radiation sources.

There is also a need for encouraging and supporting the further development of a systematic approach to the implementation of standards and guidance on occupational radiation protection through training, adapted to the needs of different target countries and target groups. The Agency should also support its Member States in their efforts to provide appropriate individual monitoring by organizing dosimetry intercomparisons.

Backfitting, upgrading and modernization of nuclear power plants

To maintain a high level of safety and reliability throughout nuclear power plant (NPP) service life, plant owners or operators should implement backfitting, upgrading and modernization programmes designed to resolve specific engineering safety and reliability issues. The IAEA should identify qualitative criteria and general principles for cost–benefit analysis that could be used in the evaluation of potential safety improvements. The Agency should also continue providing engineering safety review services to assist in the implementation of the backfitting, upgrading and modernization projects.

Utilities which own and operate NPPs that have significant safety deficiencies should prepare and implement, in the near term, backfitting programmes that would enhance the safety of these plants to an acceptable level. International assistance should be provided, as appropriate, to facilitate this work. The role of the Agency should be to define a model set of documents as a technical basis for such projects and to assist safety authorities in the safety assessment of the projects.

Ageing degradation of NPP systems, structures and components (SSCs) has an adverse effect on their integrity and functional capability and thus may threaten the availability of required safety functions. To ensure the required integrity and functional capability of SSCs important to safety, all NPPs should implement systematic and proactive ageing management programmes that integrate and co-ordinate existing NPP and external programmes that contribute to the management of ageing. The IAEA should provide guidance and safety review services for ageing management programmes.

Growing problems of obsolescence of existing instrumentation and control (I&C) systems in NPPs are driving the I&C modernization and replacement projects which introduce computer based technology into plants. Because of the inherent complexity of the technology, the designers, suppliers and NPP operators must understand the special characteristics of computer based systems and must have in place effective programmes for their design, procurement, installation, maintenance and modification to be able to demonstrate that the required system integrity has been achieved. The capability to meet these requirements must be developed by relevant organizations as the new technology is deployed. The IAEA should facilitate the exchange of experience in the licensing and implementation of I&C modernization projects, develop guidance based on this experience and implement safety review services for these projects.

Chronic exposure to residual radioactive materials

At the present time there is no established international guidance on radiological principles to guide the cleanup of contaminated areas, and the approaches and criteria being used vary from country to country. The IAEA should contribute to closing this gap by continuing its work towards creating international consensus on the principles and criteria for remediating areas affected by residual radioactive materials.

In particular the IAEA work should attempt to resolve the problems of interpretation caused by having to categorize situations as practices or as interventions — possibly by exploring the need for complementary principles to the current system of radiation protection.

Contaminated commodities, such as wood products, from areas affected by radioactive residues need to be appropriately regulated where necessary. By analogy with the approach which has been adopted for contaminated foodstuffs moving in trade, international guidance on generic non-action levels for commodities should be established.

Long term waste disposal

In view of the current questioning attitude of many people to the established view of experts that high level radioactive wastes should be disposed of deep underground without the intention to retrieve, the possible alternatives — long term surface storage and disposal with the provision for retrieval — should be critically examined by independent international groups convened by the IAEA.

There are recognized uncertainties associated with the assessment of long term radiation doses and risks to humans from the disposal of radioactive wastes and more attention should therefore be given to the development of alternative and additional indicators of safety which do not depend on the presence of humans in the receiving biosphere.

In the past much attention has been given to the establishment of safety criteria for repositories in the far future, while comparatively little attention has been directed at what is meant by compliance with such criteria. Guidance should be developed on what sort of assurance of safety would be required by the regulator in order for a repository to be licensed.

There are lessons to be learned from, and ideas shared with people involved with non-radioactive waste disposal.

Regulatory strategies

Most Member States make significant use, though to varying degrees, of probabilistic safety analysis (PSA) studies, thus demanding consistent approaches and quality, and necessitating regulatory review. The use made of PSA differs in nuclear safety, radiation safety and waste safety. It is now time to take stock, and to compile and review the experience with using PSA and to determine which are its most beneficial areas of application for the future, and what efforts are still needed to put it into practice.

The Agency should develop and publish as rapidly as possible its proposed guidance on the scope of regulatory requirements for radiation safety, covering the regulatory application of the concepts of exclusion and exemption, including clearance, and other mechanisms for release from regulatory control of low level radioactive materials.

Conclusion

In conclusion I would like to return to the plea I made on Monday, to make radiation as ordinary as possible. How far have we achieved that objective this week? My feeling is that while the overall result has been somewhat patchy we have shown by our willingness to listen and debate that we see the need to make progress in that direction. It is a major challenge but I believe we have made an excellent start.

PART B

SAFETY MANAGEMENT

SESSION CHAIRMAN'S SUMMARY OF FINDINGS AND CONCLUSIONS

Current status

The Conference reached a general consensus on the concept of safety management, on its key functions and on the components required for an efficient management of all the factors essential for the safe operation of nuclear installations. Basic for safety are sound design ensuring efficient defence in depth, quality assured construction and well planned operation which maintains the plant within its designed safety domain. But safety cannot narrowly be considered as a technical issue only and as mere compliance with rules and regulations. In future, all utilities will increasingly be challenged to enhance safety management systems and ultimately evolve towards learning organizations striving to establish and maintain a continuous improvement process. Good safety performance is an important part of the overall corporate performance. Good safety performance has to be based on a corporate commitment to a safety policy: this implies the determination of safety goals and allocation of priorities, clear lines of responsibility and communication protocols, systematic identification of hazards, implementation of control and monitoring and review of safety performance. In order to stimulate the corporate interest in safety and relate sound safety management to the financial and commercial well-being of the organization, it should be stressed that increased safety and efficiency can be achieved in parallel with controlling costs.

If shortfalls in safety occur, the ability of the utility to manage this technology safely will justifiably be challenged by the public and the nuclear safety regulator. Experience has shown that once nuclear installation performance has deteriorated to a level at which there are serious regulatory concerns about the adequacy of nuclear safety, the magnitude and difficulty of the effort required to recover performance are such that the continued viability of the organization becomes questionable. Thus, from both the perspective of individual utilities and the nuclear industry as a whole, it is extremely important to detect shortcomings and deterioration in safety management performance before it becomes a serious concern, and to put effective corrective actions in place to restore and maintain performance at high levels.

Despite increased apparent awareness worldwide of the major role played by safety management and safety culture in the safety performance of nuclear installations, many nuclear organizations have in recent years experienced serious declines in these aspects. Recent examples of organizational decline in the nuclear industry resulting in serious erosion of safety management have been highlighted at this Conference. These shortfalls in the management of safety have occurred in States with well established nuclear programmes and regulatory systems. They have, in turn, led to extensive and costly improvement programmes and intensified regulatory supervision.

For the foreseeable future, economic, political, industrial, technological and organizational changes are likely to make adaptation requirements a continuous reality for the industry. The effectiveness of management in handling these requirements can vary considerably from utility to utility. Considering extreme cases, the way these requirements are managed and nuclear safety and operational performance are integrated can either help a plant to operational excellence or destroy what was once an effective organization.

Increasing challenges to safety management will result from ageing plants, from the need to replace outdated equipment by new technological means, the loss of experienced and knowledgeable staff, the loss of institutional memory and the lack of adequately experienced and qualified replacement staff. The dynamics of change will be accelerated by the economic deregulation and liberalization of electricity markets, leaving the nuclear sector very little time to prepare for the new competitive environment, resulting among other things in cost cutting, downsizing and early retirements.

The contributed papers and presentations at the Conference provided insights into how utilities are responding to these challenges. Cases of today's utility practices in the implementation of safety management at different management levels and in the use of self-assessment and internal and external peer reviews were illustrated. Examples were given of the application of safety indicators or other sophisticated tools such as precursor evaluations to monitor success. Safety management practices related to preventive maintenance, repairs during operation or outages, as well as to education and training, were presented.

Some of these examples reach beyond current regulatory practices and demands. This underlines the need for related development in the interface between licensees and regulators. Non-prescriptive regulations and risk-informed decision making need flexibility that can only be based on sufficient transparency, predictability and mutual trust, in complete respect of the different roles and responsibilities that both sides have to fulfil.

Findings and conclusions

(1) To establish and maintain high levels of commitment, control, communication and competence in safety management organizations responsible for the safety of nuclear installations, a clear safety policy and corporate support are needed. For the implementation of safety culture, more concise practical guidance is needed. The IAEA should summarize the available concepts and experience into a key guidance document to be used by executive managers and as policy guidance. Further source documents and services should be offered which are related to appropriate oversight structures and practices, including the regulatory interface. Mechanisms for early warning in case of degradation of safety management, for corrective actions and for the feedback of their effect should be addressed.

(2) Safety management needs adequate resources, experienced personnel and institutional memory protected against short term cost cutting or downsizing. While improved safety efficiency seems to be achievable at lower cost, a common international understanding should be developed on what is necessary to establish and maintain an efficient safety management system for different types of nuclear installations. This must of course include the need to support competencies at all levels of the organization even in those States with emerging nuclear power programmes.

(3) Best efforts must be deployed at the international level towards the development of the safety management tools necessary to help reduce risk and ensure that nuclear installations remain at all times within their design basis. The Agency has a major role to play in their dissemination, and in assisting Member States in their effective use.

(4) The performance of safety management systems can be monitored by lower level safety indicators. While management systems will differ due to the different cultures of companies and national traditions, top decision makers need to know that promoting strong sustainable safety culture and achieving good safety performance makes good business sense. To this end, the IAEA could develop and disseminate safety management attributes addressed to senior management, government and senior public officials and could develop broader, lower level indicators of behavioural, organizational and process performance.

(5) Self-assessment and peer reviews are effective tools to establish, maintain and improve safety management systems. Systems should be established to enable more vigorous oversight. A proper balance between internal and external reviews should be ensured, taking the size of the utility and the national nuclear safety infrastructure into account. Openness and sufficient transparency of the individual management practices and international co-operation are key to both the credibility and the success of the management of nuclear safety.

(6) Current challenges from liberalized markets and stronger competition require a closer exchange of information related to approaches and practices between nuclear and other industries, including the related regulators, committed to efficient management of technologies requiring high safety levels in competitive environments. This competition must be committed to promoting sustainable development. Therefore, a common understanding should be developed on the principles, boundary conditions and limitations for the competition of technologies with different risk and environmental impact profiles.

PART C

OCCUPATIONAL RADIATION PROTECTION: TRENDS AND DEVELOPMENTS

SESSION CHAIRMAN'S SUMMARY OF FINDINGS AND CONCLUSIONS

Current status

The principal aim of occupational protection and safety can be stated as the achievement and maintenance of an acceptably safe and healthy working environment. With respect to the hazards of ionizing radiation, this is accomplished by applying the basic principles of radiological protection. These principles are directed at protecting workers from radiation exposure, reducing the possibility of potential exposures and mitigating the consequences of accidents.

The Conference reviewed both the state of development of protection standards for occupational exposure based on these principles and what further work needs to be done to improve their practical application. It was concluded that much progress has been made in the development of occupational radiological safety standards. The International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (BSS), co-sponsored by the Food and Agriculture Organization of the United Nations (FAO), the IAEA, the International Labour Organisation (ILO), the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (OECD/NEA), the Pan American Health Organization (PAHO) and the World Health Organization (WHO), are currently being supplemented by a number of Safety Guides and Reports. Nonetheless there would appear to be a need for further developments in a number of specific areas.

As a consequence of the emphasis given to optimization of protection, there has been a steady decline in occupational doses in a number of countries, so that nowadays workers in many industries where radiation sources are used receive total doses that are often scarcely above those they receive naturally. However, this is not universally the case; there is still scope for further application of the principle of optimization of protection. Furthermore, in recent years, there has been an increasing emphasis on those workplace situations where exposures to natural sources of radiation are high and there is some prospect for their reduction. Therefore, the optimization principle remains the most important focus of attention of the three basic principles of protection.

Findings and conclusions

(1) The ubiquity of natural radiation poses a number of problems that still need to be resolved. There would appear to be a need to develop further quantitative guidance on those situations that should be subject to control; in particular, work with materials containing elevated levels of natural radionuclides and exposure of air crews to cosmic rays in aircraft. In the context of the latter, it was recognized that there was a need to determine whether the exposure is amenable to control and, if so, what sort of controls

might be applied. International harmonization in this area would seem essential.

(2) The principle of optimization of radiological protection is, in occupational protection, implemented essentially through proper management and successful application of work management strategies. The Conference noted that there have been considerable reductions in the levels of occupational exposure to radiation, especially in the nuclear power industry. It was noted, however, that a balance had to be struck between the protection of the worker, e.g. by reducing the frequency of maintenance tasks involving high doses, and nuclear safety, in terms of the public radiation risk reduction which is expected to result from these maintenance tasks. To facilitate the achievement of this equilibrium, a transparent and improved communication between the nuclear safety and the radiation protection groups is of vital importance.

(3) The principle of optimization of protection has also been applied outside the nuclear industry, e.g. in general industry, in research, teaching and in the medical field. Nevertheless, there would still appear to be considerable scope for further improvement in its application. Particular target groups for improvement are underground miners (not just miners working in uranium mines, but also those working in other types of mines exposed to relatively high levels of radon), industrial radiographers and interventional radiologists. But in some countries the needs are more general. This calls for the development of further practical guidance, as well as assistance in encouraging the development of commitment to the principle of optimization of protection, for example through training.

(4) Although the implementation of the principle of optimization of radiation protection in operations is to a large extent a managerial problem, it should also be noted that real time electronic dosimetry, which is becoming more readily available, will considerably improve the situation in that it facilitates feedback and helps the individual worker take responsibility for her/his exposure. Another important tool in the optimization process is the use of reference levels. In particular, the application of investigation levels should be encouraged, as these should be used to initiate review with a view to learning lessons for future operations. Such levels can be used in all areas of occupational exposure. The use of databases to provide feedback was also noted and encouraged by the Conference.

(5) In its 1990 Recommendations, the International Commission on Radiological Protection (ICRP) made the judgement that the effective dose limit for occupational exposure should be set at a level such that the total effective dose received in a full working life would be prevented from exceeding about 1 Sv, received more or less uniformly. Dose limits for occupational exposure were based on this and included provision for averaging of the effective dose over five years. The Conference, however, noted that the occupational dose limits may well be applied differently in different countries, leading to a lack of harmonization throughout the world, which would be regrettable.

(6) Some concepts that are relevant to the implementation of protection standards were identified as being especially in need of further practical development. These include the use of dose constraints in design and in planning operations and the designation of areas. There is also a need to share experience on the management of pregnant workers in order to understand the issues involved.

(7) Measurements related to the assessment or control of exposure to radiation and radioactive materials play a major part in any radiological protection programme. Monitoring, including the interpretation of the results and the dose assessment, helps to achieve and demonstrate adequate compliance with radiation protection requirements. Further harmonization is needed in the application of the operational quantities for radiological protection. There is also a need to review whether both penetrating and superficial doses from external radiation sources should be measured routinely. To encourage a universally high quality of dose measurement and assessment, the organization of international intercomparison exercises for both external and internal dosimetry is very valuable and should be encouraged.

(8) Technical services responsible for occupational monitoring are now available in many countries. There is, however, a lack of internationally agreed criteria for defining requirements of technical services to be accepted by the Regulatory Authority. The BSS require a quality assurance (QA) programme to be established as part of radiological protection. Extensive guidance for the development of a QA system is given in reports of the International Organization for Standardization (ISO) and the International Electromechanical Commission (IEC), but further guidance is needed on the interpretation and implementation of these standards.

(9) There is also a need for encouraging and supporting the further development of a systematic approach to the implementation of standards and guidance on occupational radiation protection through training programmes which are tailored to the needs of different target countries and target groups and organized on a national, subregional or regional basis. One particular target audience for understanding radiological protection issues is that constituted by the occupational health physicians, who should have the appropriate knowledge of radiation risks and principles of protection in occupational exposure to advise management and workers. Some concern was also expressed about the loss of experience in the profession of radiological safety as people retire. This reinforces the need to establish and maintain appropriate training programmes for professionals.

(10) Protection standards need to keep pace both with the developments in the underlying science and with developments in technology that might have implications for health and safety systems. There is a need to anticipate, as far as possible, such developments and there could be some merit in setting up a study team to consider such matters at an international level. This expert group should have a broader remit than just occupational protection and consider, for example, the implications of policies regarding safety and public protection on occupational exposure.

PART D

BACKFITTING, UPGRADING AND MODERNIZATION OF NUCLEAR POWER PLANTS

SESSION CHAIRMAN'S SUMMARY OF FINDINGS AND CONCLUSIONS

Current status

NPP operators and regulators seek to ensure, throughout NPP service life, that plant safety and reliability levels are acceptable in comparison with current standards. Safety and performance reviews (e.g. periodic safety reviews, ongoing safety assessments, peer reviews and self-assessments) are used to identify any shortcomings, to determine practical improvements and to plan a programme of implementation.

Corrective actions of an engineering nature usually take the form of NPP backfitting, upgrading and modernization programmes or activities. Both qualitative and quantitative approaches are used in the selection and prioritization of corrective actions or safety improvements.

Ageing degradation of NPP systems, structures and components (SSCs) has an adverse effect on their integrity and functional capability and thus may threaten the availability of required safety functions and plant life. Experience clearly shows the benefits of proactive ageing management (e.g. as practised in relation to reactor pressure vessel radiation embrittlement) in comparison with a reactive approach (e.g. that applied to steam generator corrosion). Therefore, systematic ageing management programmes are being implemented by an increasing number of utilities and required by an increasing number of safety authorities, often as a part of life management programmes which involve the integration of ageing management and economic planning.

The majority of western NPPs built to earlier standards have been or are being backfitted to remedy their design safety deficiencies. However, there is significant variation in the present safety status of individual WWER and RBMK NPPs. Some countries have implemented only some interim urgent compensatory measures while other countries are in an advanced stage of major backfitting. The progress in the implementation of these major backfitting programmes is dependent on available financing, which is linked to the economic situation of individual countries and varies significantly.

Growing problems of obsolescence of existing I&C systems in NPPs are driving I&C modernization and replacement projects which introduce computer based technology into plants, including the safety systems. The regulation of these systems has proved a difficult and protracted experience due to fundamental concerns about the ability of the suppliers, utilities and experts to demonstrate the high reliability claimed for software embedded in computer based systems. Because of the inherent complexity of software, the designers, suppliers and NPP operators must understand the special characteristics of computer based systems and must have in place effective programmes for their design, procurement,

installation, maintenance and modification to be able to demonstrate that the required system integrity has been achieved. The capability to meet these requirements must be developed by relevant organizations as the new technology is deployed.

The external hazard re-evaluation of many NPPs designed to earlier standards has not been performed. In the USA all NPPs have gone through this process, along with upgrading as required. Similar work has been partially carried out in western Europe, Japan, the Republic of Korea and Pakistan. In eastern Europe, most NPPs have performed seismic capacity re-evaluations and implemented 'easy fix' programmes. Several NPPs also require structural upgrades, which are generally held up because of financial constraints.

The IAEA has been assisting Member States by providing safety standards, guidance documents and safety review services.

Findings and conclusions

(1) To maintain a high level of safety and reliability throughout NPP design life and preserve the option of plant life extension, all NPP owners or operators should implement backfitting, upgrading and modernization programmes to resolve engineering safety and reliability issues identified by routine, special and periodic safety reviews and feedback of operating experience. All issues that arise should be evaluated to ensure that those which challenge the acceptable level of safety are effectively resolved.

(2) Both qualitative and quantitative approaches, including PSA and cost–benefit analysis, should be used in the selection and prioritization of corrective actions or safety enhancements. It would be beneficial to identify for this purpose the qualitative factors and general principles for cost–benefit analysis. Qualitative factors to be considered include the improvements in redundancy, separation and diversity and the feasibility, complexity and novelty of implementing the corrective action, taking account of the related dose to workers.

(3) Any interactions between various issues, as well as the safety margins embedded in the design and the uncertainties of safety assessment methods, should be considered. All of the people involved in the implementation of plant modifications, including NPP operations and maintenance staff, design and construction engineers and safety analysts, should participate in the decision making.

(4) To assist Member States, the IAEA should facilitate the identification of generic safety issues and the safety enhancements that resolve these issues effectively. The Agency should also continue providing engineering safety review services (design, siting, ageing management, fire safety, software safety) to assist in the implementation of the backfitting, upgrading and modernization projects.

(5) Utilities which own and operate NPPs that have significant safety deficiencies should prepare and implement, in the near term, backfitting programmes that would enhance the safety of these plants to an acceptable level. International assistance should be provided, as appropriate, to facilitate this work.

(6) To assist Member States in the implementation of major backfitting projects, the Agency should provide appropriate advice, including advice on the documents needed as a technical basis for such projects.

(7) To ensure the required integrity and functional capability of SSCs important to safety and to preserve the option of plant life extension, all NPPs should implement systematic and proactive ageing management programmes that integrate and co-ordinate existing NPP and external programmes relevant to the management of ageing.

(8) The IAEA should develop guidance for safety based prioritizing of ageing management actions, and continue to integrate Member States' knowledge and experience on effective ageing management of selected SSCs.

(9) All Member States in which older NPPs are being operated and seismic re-evaluation has not been performed should check the seismic safety of these plants with the aid of the systematic programme for seismic re-evaluation and upgrading.

PART E

SITUATIONS OF CHRONIC EXPOSURE TO RESIDUAL RADIOACTIVE MATERIALS: DECOMMISSIONING AND REHABILITATION AND RECLAMATION OF LAND

SESSION CHAIRMAN'S SUMMARY OF FINDINGS AND CONCLUSIONS

Current status

The application of the concepts of practices and interventions has caused some misunderstanding and confusion with respect to chronic exposure situations. Protection principles are therefore being further developed by the IAEA and ICRP. New ideas have been launched which include generic action/non-action levels for remedial measures expressed as total individual dose, irrespective of the source. General principles and guidelines on protection of the public against chronic and quasi-chronic exposures are being developed by the ICRP. As for previous recommendations from the ICRP, they would function more as a basic protection philosophy for chronic exposure situations, rather than as practical guidelines for specific exposure situations.

When considering possible approaches for the justification and optimization of remedial measures for mining and industrial sites contaminated by naturally occurring radionuclides, remediation should be justified based on appropriately established non-action levels.

In the past there have been interventions proposed or carried out to rehabilitate land contaminated during the era of atmospheric nuclear weapons testing. Pragmatic judgements have led to interventions and so far produced outcomes that are more or less consistent with each other and with present intervention philosophy. Cases still to be evaluated will no doubt be amenable to similar intervention responses. Some, such as the French sites in the South Pacific which were the subject of a recent international assessment co-ordinated by the IAEA, are unlikely to require any further remediation. Others, such as the former USSR test site at Semipalatinsk in Kazakhstan, will require further study before decisions can be taken about their future rehabilitation.

The 465 nuclear weapon tests conducted at Semipalatinsk over a 45-year period resulted in locally contaminated areas of up to 3.7 TBq/km^2 ^{137}Cs, 370 GBq/km^2 $^{239+240}$Pu and 5.5 GBq/km^2 ^{90}Sr. Annual effective doses from these localized areas inside the test site were estimated to be 14 mSv for visitors and 140 mSv for future inhabitants. In settlements outside the test areas the annual effective doses were up to 0.14 mSv.

Uranium mining and milling tailings in Kyrgyzstan had resulted in some contamination of river water and bottom sediments in Uzbekistan.

In the USA there is no unified legal and regulatory framework for residual radioactive materials. Radioactive contamination from non-uranium mining and from oil and gas production has been regulated separately from nuclear fuel cycle material. Regulators differed on whether standards should be regarded as goals or limits, whether all pathways should be regulated in a unified manner, or whether separate controls should be required for different media.

In the context of the risk perception of chronic exposure following accidents, it has been shown that negative or immoral concepts are often perceived as non-natural phenomena. Natural phenomena are normally associated with what is viewed as valued and beneficial. Human intelligence, for example, is most often perceived as natural, whereas human violence is seen as non-natural. Uranium and radiation tend to fall in the middle of the spectrum. This perception of natural versus unnatural may be important in understanding how individuals perceive events and terms such as 'natural radiation', 'radiation' and 'man-made radiation' that are associated with the nuclear field.

Findings and conclusions[1]

(1) The intervention concepts developed by the ICRP and the IAEA will guide policy makers towards solutions that optimize the use of limited resources in the way envisaged by these bodies. It would be beneficial to establish a generic reference level or non-action level constraining the optimization of remedial measures in chronic exposure situations. A reference level should be individual-related rather than source-related. Further work is needed in preparing guidelines on protection principles for a number of long lasting exposure situations using the methodology for derivation of generically optimized criteria. It is recommended that the IAEA proceed along these lines.

(2) The ultimate decision on a remediation option should be the result of a site specific analysis using realistic assumptions on exposure pathways and calculation parameters. Any programme of remedial action should be carefully considered to avoid raising public concern or unjustified financial expenditure.

(3) From a regulatory point of view it seems to be preferable to use a single generic action level of around 10 mSv/a in the decision making for justifying and optimizing remediation. In some circumstances, and recognizing that public authorities may have different approaches to the control of radon, it might be appropriate to set a different standard for exposures from radon and radium-bearing materials.

(4) The key to managing nuclear accidents lies in preparedness on three fronts: the political, the technological and the psychological. Preparedness may be enhanced by accepting discussions of fear fantasies, attempting some visualizations of daily problems and their solution in long term post-accident situations, and thus attempting to come to terms with extreme or non-probable scenarios before they appear in less controlled contexts.

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[1] See also the Conference Chairman's report (Part A).

(5) A study has shown that 'natural radiation' is perceived as more acceptable than 'radiation' or 'man-made radiation'. This perception is important when dealing with the public on issues concerning remediation and accident situations.

(6) In order to enhance an expert's public credibility and acceptability, effective networking directed at the media, environmental and political groups while conditions are normal will prove invaluable when communicating risks from accidents.

PART F

RADIATION SAFETY IN THE FAR FUTURE: THE ISSUE OF LONG TERM WASTE DISPOSAL

SESSION CHAIRMAN'S SUMMARY OF FINDINGS AND CONCLUSIONS

Current status

Safe disposal of low level radioactive waste containing limited concentrations of long lived radionuclides is being practised in many countries. Methods for disposal include near surface disposal and disposal in mined cavities without reliance on active institutional controls for more than 100–300 years. Tailings from the mining and milling of uranium ores, which contain significant concentrations of long lived radionuclides such as ^{226}Ra, are also disposed of in near surface impoundments, but greater reliance is placed on institutional controls to achieve safety.

As yet, no country has an operating facility for disposal of high level radioactive waste (HLW), but most countries with nuclear power programs have an activity to develop the technology for HLW disposal. There is agreement among waste management experts that mined geologic disposal, using a combination of engineered and natural barriers to isolate the waste, is the preferred technology for this purpose. Several countries are conducting site investigations and research programs with the aim of selecting suitable sites early in the next century. Lack of public acceptance of the siting of HLW repositories has been a continuing obstacle in most countries.

Findings and conclusions

(1) Although geologic disposal without the intention to retrieve the waste is seen as a permanent solution by most experts, consideration has also been given to the potential value of being able to retrieve the waste. Retrieval of the waste can be achieved both during the operational phase of the repository and during the post-closure phase even if the latter may require considerable resources. It is important that retrievability should be accomplished without endangering the safety of the system.

(2) Storage of waste should not be seen as an alternative to geologic disposal as it is not a permanent solution. On the other hand, geologic disposal with the possibility of retrieval offers a permanent solution (disposal) with an option to retrieve the waste if future generations so wish. However, there are a number of issues such as duration, interaction with overall repository safety and degree of retrievability that need to be examined. In summary, an international assessment of the safety and other implication of the options of disposal (with and without retrievability) and of long term storage, would be valuable.

(3) There are recognized uncertainties associated with the assessment of long term radiation doses and risk to humans from the disposal of radioactive waste. Moreover,

the relationship between dose or risk and health detriments may change in the far future as the characteristics of the society change. Therefore, if it appears necessary to carry out safety assessments for long time scales, these quantities should be considered as safety indicators rather than as measures of the safety of the system.

(4) The corresponding information should be given to the decision maker in a disaggregated way, making a distinction between the likelihood of the events resulting in the exposure of a critical group and the levels of exposure. More attention needs to be given to the development of additional indicators of safety, especially those related to the environment. For this purpose, comparators or safety criteria to be used for understanding the acceptability of the calculated values of these indicators need to be developed.

(5) Recognition of the increasing uncertainty of assessments with time has prompted proposals for the development of stylized approaches to estimating dose in the far future by establishing 'hypothetical critical groups' and 'reference biospheres'. It would be beneficial to unify these developments so as to promote consistency of approach and to allow comparisons to be made. The projects being co-ordinated by the IAEA to establish internationally agreed stylized approaches in this area are therefore supported.

(6) Assessment of the impact of geologic repositories on humans or on the biosphere at times approaching one million years should not be seen as predictions of the future evolution of the repository but rather as tests of the robustness of the system.

(7) In the past much attention has been given to the establishment of safety criteria for repositories in the far future, while comparatively little attention has been directed at what is meant by compliance with such criteria. Guidance should be developed on what sort of assurance of safety would be required by the regulator in order for a repository to be licensed. Account should be taken not only of the compliance with the quantitative values set for the safety criteria but also of the way in which the development of the repository has been carried out (competence of the operators, transparency of the process, documentation of the selection of the technical option, etc.). In other words, the compliance issue is a complex one in which the decisions are based on both quantitative and qualitative elements. More guidance needs to be developed on what constitutes compliance.

(8) Experts have the responsibility for the development and evaluation of waste safety. Waste management is, however, not only a matter for the experts. In a democratic society the views of the general public must also be taken into account. It should be pointed out that the opinions of the general public may offer valuable insights, but their views must never be allowed to compromise safety.

(9) The problems faced in assuring the long term safety of the geologic disposal of radioactive waste and non-radioactive toxic waste are similar. To date, the problems have been dealt with separately by the respective technical communities. There are potential benefits to be obtained by both communities from technology exchange, for example in the areas of safety principles and criteria, performance assessment and risk communication to decision makers.

(10) Past experience in the field of long lived waste disposal and conceptual reflections in this field indicate that experts should avoid presenting specific solutions as being unique and without any other options. This is the case with the dogma of 'concentrate and retain' rather than 'dilute and disperse', or with the understanding of disposal as meaning isolation without the possibility of retrieval. An open-minded and pragmatic approach should be favoured insofar as it fits within a safe and coherent system, keeping in mind the fact that there are different kinds of radioactive wastes with different disposal requirements.

PART G

REGULATORY STRATEGIES

SESSION CHAIRMAN'S SUMMARY OF FINDINGS AND CONCLUSIONS

Current status

The safety performance of regulated activities in the last decade has shown continually improving trends worldwide, particularly with respect to equipment performance and reduced frequency of serious incidents. Regulatory authorities have made improvements in their programmes over the last ten years, partly as a result of increasing international review of regulatory practices and developments such as the Convention on Nuclear Safety and safety guidance promulgated by the IAEA. Despite these improvements, several serious breakdowns in safety management performance and associated safety culture have occurred in Member States, which had not been detected by the licensed organizations. These breakdowns were not identified promptly by regulatory authority programmes.

External factors in a changing environment which are expected to affect regulators and the regulated organizations over the next several years include a declining and ageing nuclear plant population, increased economic pressure on nuclear utilities, financial pressure on regulatory authorities by their respective governments, the effect of increased competition and privatization, continued growth in industrial and medical uses of radiation sources, and delays in decision making about dealing with high level waste.

The key to regulatory quality and effectiveness was acknowledged by the Conference to be the competence of the regulatory authority personnel. The following set of strategic recommendations is proposed in order to respond to the changing environment and to prevent serious deterioration in human performance, with suggested measures for improvement in effectiveness and efficiency of regulatory activities, and to promote harmonization of regulatory practices.

Findings and conclusions

(1) The IAEA should conduct meetings to prepare a plan of action regarding guidance on how to assess and inspect effectively the safety management of an operating organization. The guidance should cover assessment of safety management, organizational aspects, human performance and self-assessment. The meetings would bring together best available practices among Member States and identify areas which need further development.

(2) The IAEA should develop and publish as a high priority its proposed guidance on the scope of regulatory requirements for radiation safety, covering the regulatory application of the concepts of exclusion and exemption, including clearance and other mechanisms for release from regulatory control of low level radioactive materials.

(3) In order to improve regulatory effectiveness and efficiency and to assist Member States in optimizing the prescriptiveness of their regulations, a comprehensive review of Member States' regulatory practices for nuclear, radiation and radioactive waste safety is needed. The areas to be covered should include the legislative basis and system of regulations, and the degree of prescriptiveness in the light of current trends. The results of the review would provide a basis for developing guidance on applying the best regulatory practices.

(4) Since considerable progress in and use of PSA has been made by regulatory bodies, it would be beneficial to compile Member State experience and plans for the use of PSA methodology in nuclear, radiation and radioactive waste safety. Meetings on this topic would provide a basis for developing guidance in areas such as the precursor programme described during the Conference which quantitatively assesses incidents and equipment degradation in nuclear power plants.

(5) It would be useful to survey future needs and the projected availability of nuclear professionals and technological capabilities among Member States in order to consider the need for long term strategic actions to meet any shortfalls in professional skills and any erosion of the knowledge base. Special attention should be paid to the use of rapidly developing information and communication technology and to ensuring exchange of knowledge and experience between senior professionals, especially those close to retirement or retired, and the new generation of engineers and scientists.

(6) Recognizing concerns about the capability of Member States to communicate effectively with today's highly reactive media and with the public, meetings should be conducted to assist representatives of regulatory organizations and regulated practices to improve their communication skills. Such skills are especially valuable in communications following an incident.

(7) During the Conference it was suggested that there is a need for data and information from Member States' regulatory bodies on experience in regulatory decisions. Such information would be valuable to other Member States facing similar issues. The IAEA should strengthen its efforts to collect and disseminate this information, for example through the Agency's web site.

(8) To assist in dealing with difficult regulatory decisions, experience and lessons learned from other industries should be reviewed, including experience in civil aviation and the chemical industry. A meeting should be held to discuss the knowledge gained and its possible bearing on regulatory practices in nuclear and radiation safety.